Immersive Research Experiences: Influences on Science Teaching Motivation and Practices

Lindsey Hubbard
North Carolina State University, United States

Stella Jackman-Ryan
North Carolina State University, United States

Margareta Thomson
North Carolina State University, United States

Abstract

The push for inquiry-based learning in science classrooms has been met with anxiety and oftentimes low teaching self-efficacy among science teachers (Martin, et al., 2019). Professional development offers an opportunity for teachers to gain confidence through experiencing a real research lab. The current study investigates the outcomes of an extensive 8-week professional development program (*N*=8) on teachers' classroom instruction and explores the influential factors in instructional change. Focus groups and individual interviews were conducted to understand teacher's PD experiences. Three major themes emerged: model the actions of scientists, evidence of inquiry-based instruction, and evidence of self-efficacy. Professional development opportunities including an immersive lab experience, opportunities to build a learning community, and opportunities to feel like a student are influential to changes towards are more inquiry-based learning approach in the classroom and higher self-efficacy. When seeking opportunities for professional development for high school science teachers, school leaders and science teachers should search for key features that promote changes in the classroom leading to more inquiry-based learning.

Keywords: inquiry-based learning, professional development, research experience, science education, teaching self-efficacy

Teacher professional development has long been a remedy for many issues in education, however, there is dissension on the effectiveness of how it is implemented (Borko, 2004). Pressures for education reform often result in the push for the elusive solution of the professional development for teachers without clear guidelines on how, when, and to what extent it should be required and implemented (Thomson & Nietfeld, 2016; Borko, 2004). When the National Research Council (1996) suggested that science be taught in a way that is consistent with the scientific inquiry used within the field, professional development was the natural solution to getting science teachers up to par on national science standards. The standards outlined in the document suggested that students should be learning science in the same ways as real-world scientists would in their fields (National Research Council, 1996, 2000).

One major issue regarding the science education reform is that many science teachers had no prior experience in approaching science teaching in a way that was conducive to inquiry-based learning (Anderson, 2002; Thomson & Gregory, 2013; Crawford, 2007). They have become responsible for developing and facilitating innovative lessons in the classroom that fall outside of the typical pedagogical and methodological teachings of their teacher preparation programs (Bayar, 2014). Inquiry-based instruction requires access to resources, support from peers and school leaders, and overcoming barriers to deeply understanding science content (Johnson, 2006).

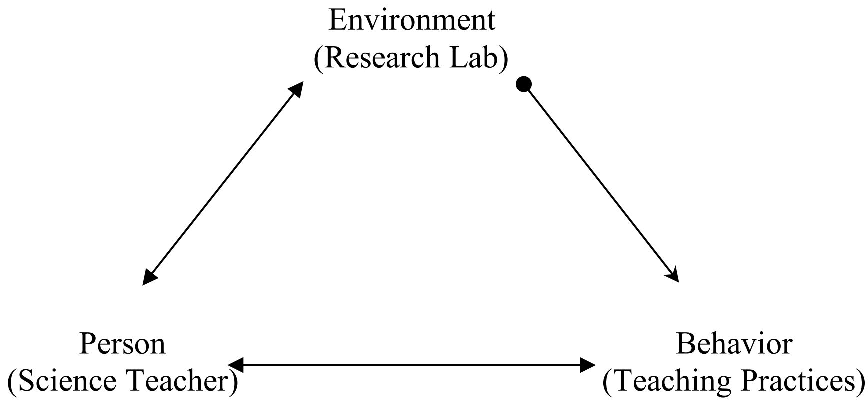
Professional development offers critical support to teachers by equipping them with tools, resources, and key experiences to overcome barriers in science teaching (Johnson, 2006). It has been shown to impact teachers' self-efficacy and classroom outcomes (Thomson & Turner, 2015; Klein-Gardner, Johnston, & Benson, 2012). The professional development experience detailed in this study is an 8-week summer program for high school science teachers who work in low-performing schools. The program is built on an immersive lab experience that allows for inquiry-based learning, mentorship, and networking. This current study reports on the data from one year of a larger, 5-year longitudinal study (Thomson, Roberts, & Hubbard, 2020). It aims to examine how professional development can influence teachers' science-teaching practices and beliefs about their capabilities. The study is guided by the following research questions:

1. In what ways do teachers' experiences from a summer immersive research mentorship program influence instructional practices?
2. What changes in teacher motivations (i.e., their teaching self-efficacy and values) are attributable to program participation?

Theoretical Framework

Social cognitive theory (Bandura, 1977) draws connections between learning and behaviors formed through, "reciprocal interactions; enactive and vicarious learning; the distinction between learning and performance; and the role of self-regulation" (Zimmerman & Schunk, 2003; Schunk, 2012, p. 119). Reciprocal interactions are described by Bandura (1982a, 1986, 2001) as a three-part cycle involving the person, their environment, and their behaviors. Figure 1 is a model interpreted from Bandura (1986) showing the nature of the reciprocal interactions. This model includes "science teacher" as the person, "teaching practices" as the behavior, and "research lab" as the environment in which learning takes place.

Figure 1
Reciprocal Interactions within Professional Development (adapted from Bandura, 1986)



When focusing on the relationship in the triad between the person and their behaviors "self-efficacy beliefs influence such achievement behaviors as choice of tasks, persistence, effort expenditure, and skill acquisition" (Schunk, 2012, p. 120; Schunk & Pajares, 2002). Self-efficacy refers to one's personal belief about one's ability to effectively learn or perform a task. It is not the same as one's actual ability to perform the task.

Both enactive and vicarious learning occurs without an explicit action completed by the learner. Enactive learning includes learning from the failures, successes, and consequences of others. Vicarious learning occurs through the observation of models, while not actually performing the task simultaneously. Models can take on many forms including in-person, symbolic, electronic, or in print (Schunk, 2012).

Social cognitive theory assumes that people engage in self-regulated behavior as they perceive themselves as having an agentic role in the performance of their learned behavior (Bandura, 1997). In regulating their behavior, people undertake actions that are likely to yield positive outcomes and abandon those that yield unrewarding outcomes (Bandura, 2001). Self-efficacy is pivotal to a person's sense of agency. Through self-efficacy and self-regulation, individuals evaluate their skills and capabilities to transform them into actions (Bandura, 2001).

Social cognitive theory, as a theoretical framework for this paper conceptualizes how teachers in this study learned through their immersive lab experiences, and how self-efficacy served as a catalyst for their changes to instruction when they returned to the classroom.

Literature Review

Inquiry-Based Learning in Science Education

Over the last several decades, science education reform has advanced inquiry-based learning and instruction as best practice for science learning and teaching (Anderson, 2002; Crawford, 2000; Johnson et al., 2020). This instruction involves "investigating questions and using data as evidence to answer these questions" and paves the path for students to understand the nature of science (Capps & Crawford, 2013, p. 498). Learning in this manner "should reflect the nature of scientific inquiry" (Anderson, 2002, p. 2). Inquiry based learning should "model the actions of scientists", however, the extent to which teachers understand the actions of scientists presents a problem to implementation (Crawford, 2007, p. 614).

Barriers to learning any subject exist in each classroom and may depend on individual students and teachers (Crawford, 2007). When it comes to science learning and teaching, barriers preventing effective learning come from all sides including, lack of teacher experience and preparation in science inquiry (Capps & Crawford, 2013; DeCoito & Myszkal, 2018), low self-efficacy among students and teachers (DeCoito & Myszkal, 2018), and perception of support and school culture (Crawford, 2007). Many teachers have little understanding and experience in science inquiry and because of this limited experience, they find it difficult to navigate science inquiry in their teaching practices (Capps & Crawford, 2013). Crawford (2007) makes an important distinction that the difficulty in teaching through science inquiry is not at the fault of teachers, but may be largely caused by the fact that "researchers and teacher educators do not agree on what is meant by using inquiry in a science classroom" (p. 618).

Inquiry-based learning has been conflated with other terms like "doing science, hands-on science, and real-world science", all of which give a clear picture of the level of involvement required of students in their science learning experiences, but do not accurately capture the level of guidance in inquisition required to meet the students' learning needs (Crawford, 2000, p. 918). These conflated terms may derail teachers from truly meeting inquiry-based standards (Anderson, 2002; Crawford, 2007). Martin, Park, & Hand (2019) found that teachers beliefs about students learning science through inquiry and their choices in the classroom are sometimes at a disequilibrium resulting in science teaching that does not truly reflect inquiry-based instruction.

What teachers know and believe about science, teaching, and their own knowledge shapes their choices in planning and teaching in their science classrooms (Crawford, 2007; Martin, et al., 2019). A teacher's knowledge about science content or about teaching practices will "shape how the teacher might respond to student questions and inquiries" (Crawford, 2007, p. 615). People will avoid situations that they believe require abilities beyond their own; alternatively, people will "behave assuredly when they judge themselves capable of handling situations that would otherwise be intimidating" (Bandura, 1977, p. 194). For teachers who have little understanding of inquiry-based instruction, they are unlikely to engage their students in inquiry-based learning; therefore, increased self-efficacy in science content and pedagogy is necessary for high quality instruction (DeCoito & Myszkal, 2018). Professional development offers the opportunity to provide teachers with experiences to increase their self-efficacy.

Professional Development in Science Education

Traditionally, PD in science education has centered around introducing new curriculum and instructional materials, enhancing teachers' content knowledge, improving pedagogical approaches, or training about scientific inquiry (Wilson, 2013). Although widely established as a response to educational reform, PD programs have functioned without clear operational guidelines (Borko, 2004). Today there are a myriad of PD options available to teachers ranging from summer programs, school-based professional learning groups, and immersive research experiences to coaching and mentoring (Wilson, 2013), often differing in length (Supovitz & Turner, 2000).

Scholars have sought to identify the key operational components of PD programs that impact teacher learning and knowledge transfer. Borko (2004) asserted that PD programs must target subject knowledge, understanding of student thinking, and instructional practices. Explicit attention to the subject matter and engaging teachers as learners in PD activities are particularly helpful to teachers building on knowledge independently. Immersive experiences where teachers are actively engaged with inquiry opportunities, as well as models of inquiry teaching, have been identified as critical turning points for teachers in PD (Wilson, 2013; Borko, 2004; Supovitz & Turner, 2000). An understanding of how students develop ideas and form connections are also critical components of effective PD (Borko, 2004). Wilson (2013) also reported that "focusing on specific content and engaging teachers in active learning" are general characteristics of effective PD (p. 310).

Borko (2004) provides a map of professional development in which teachers, the PD program itself, and facilitators are all within the greater context of the PD program, concluding that sound research would focus on the impact of each of these factors within the PD system. The overarching aim of the study is to examine each of these factors within the program we've designed. For the focus of this paper specifically, we aim to examine the impact of the program on the teacher participants.

Methodology

Study Context

The current study is part of a larger research project (Thomson et al., 2020) in which 5 cohorts of teachers over a 5-year timeframe participate in an 8-week summer immersive research program with a focus on environmental health science. The project, funded by the National Institute of Health (NIH) aims at increasing science teaching self-efficacy by equipping teachers with resources, experiences, and content knowledge relevant for incorporating inquiry-based instruction into their teaching practices.

The context of the PD program includes: immersion into a research lab, a mentor scientist/lab, guest speakers and lecturers, monetary compensation including funding for lab supplies for the classroom, access to university resources including world-class laboratories and libraries. Research labs from an environmental and human health research group at a southeast R1 university are recruited to be hosts and mentors for the 8-week summer PD program. Participants reported to these labs 4 days per week and spent approximately 8 hours in the lab during each visit. One day per week they joined together with the research team for guest lectures, collaboration, and focus groups. Within this group time, teachers were together with their peers and reflected on their experiences freely with one another.

Some teachers were partnered with labs that did not overlap with their course content. Within the labs, most teachers developed their own research questions, designed their study, and conducted the research and analysis under the close supervision of the mentor lab scientists and their graduate students. At the end of the PD, teacher participants produced a poster to showcase their research.

Research Design

A single instrumental qualitative case study design was employed following a bounded system approach as described by Yin (2014) and Creswell & Poth (2018). Only qualitative data were used (i.e., interviews and focus group) as we investigate the experiences of a single cohort of teacher participants (the 2018 cohort) in the summer PD program.

Participants

Participants in the summer program (*N*=8) were all certified high-school science teachers from public schools with many economically disadvantaged students. Participants' demographic data is presented in Table 1.

Table 1
Teacher Participant Demographic Features

Participant	Race/ Ethnicity	Gender	Yrs Teaching Experience	Subjects Taught
Dylan	AA	F	18	Biology, physical science, earth science, AP Biology
Gabi	AA	F	20	Anatomy, biology, physical science, forensics, AP environmental science, AP Chemistry
Jay	AA	F	4	Chemistry, Biology, Physical Science
Kori	W	F	3	Biology
Trey	AA	F	24	Chemistry, Physical Science, Physics, Earth Science
Pat	AA	F	5	Physical Science, Biology, Chemistry, AP Biology, Health, Biomedical Science
Rori	AA	F	4	Career and Technology Education, Environmental Science, Biology, Biomedical Science
Blake	AA	F	5	Physical Science

All teachers were female with a majority having teaching experience less than 10 years (only three teachers had more than 10 years' experience in teaching). Furthermore, seven participants identified themselves as African American and one as White Caucasian. Participants were recruited through emails and word of mouth from school administration. Some participants received an email directly from the PI on the project, others received the email from administration and other school representatives.

Teachers interested in the program applied via an online application. The following criteria was used in accepting applicants into the program: teachers that taught at schools with a higher free and reduced lunch percentage, teachers that had less than 10 years of experience in teaching science in high school classrooms, and teachers that expressed interest in conducting lab research. Due to the applicant pool in the first year of the project, teachers had a wide range of years of experience, from 3 years to over 15 years.

Procedures

Major qualitative data sources include open ended survey questions, online discussion and reflection forums, two focus groups, and individual, semi-structured, phone interviews. For the scope of the current study, major data sources are two focus groups and six individual semi-structured, phone interviews (see sample questions in Appendix A).

Focus group interviews

Focus group 1 was collected at the end of week two of the program and lasted approximately one hour. All participants were present and active for this focus group. Focus group 2 lasted approximately 30 minutes and was conducted in week eight. Only seven participants were present for this focus group as one teacher moved to a new state the week prior and was unable to attend. Both focus groups were conducted in rooms that were familiar to the participants and were moderated by the principal investigator and recorded by the research assistant.

Individual interviews

Individual semi-structured interviews were collected 3-4 months following their summer program participation, at the end of their first school semester. Two teachers never scheduled an interview, therefore, only six interviews were collected. These interviews focused on possible changes that teachers reported making in their teaching after participating in the program. Interviews lasted between 20-30 minutes for each participant and were collected by the research assistant and an additional graduate student advised by the principal investigator.

Data Analysis

The purpose of the focus groups was to understand the challenges, values, and experiences of the participants during the PD program. The aim of the individual interviews was to gain insight into individuals' reflection of their program experience as well as understand any changes made to their approach to science teaching. The purpose of data analysis was also to understand the connections between participants' experiences in the program with their self-efficacy in teaching science through inquiry-based instruction.

Focus groups and interviews were recorded and transcribed. All transcribed data were coded by two primary coders. Phase one of analysis used open coding to observe emerging themes that might collectively provide insight into the research questions (Merriam & Tisdell, 2015). Phase one presented approximately 100 codes that were then combined to account for differing codes that were describing the same type of data. In phase 2, axial coding was used group codes into themes while also using the constant comparative method, combining the cycle methods and open coding (Miles, Huberman, & Saldana, 2014; Strauss, & Corbin, 1998). Codes that did not directly apply to the research questions were eliminated. Three major themes emerged from the codes: focus on the students, teachers' self-efficacy gains, science teaching changes (see Appendix B).

Findings

The purpose of the current study was to understand how participants' experiences in the PD program impacted their science teaching, as well as changes in their teaching self-efficacy. Generally, teacher participants were excited to participate in the PD program and despite challenges, left the program with a sense of pride in their work and research. Throughout the program teacher participants' focus remained on their students. Student engagement was a major motivation for applying to and completing the PD program for teachers. Teacher participants felt connected to their students as they were in a new role as learners. The continued focus became the first major theme of *focus on the students.* Participants' reported a renewed excitement for science and for teaching their science content. Even when teacher participants reported expecting low support from their school administration, they made notable changes to their science teaching instruction and overall beliefs about teaching science. Teacher participants' spoke about their confidence, excitement, enjoyment, and pride in their ability and work led the coders to the second theme of *teachers' self-efficacy gains*. Teacher participants largely expressed their belief in their own ability to be a scientist, even when they reported being certain they wanted to remain in education. The in vivo code "I did, so I know you can" served as a bridge from views of ones' self to views of students. Teachers were able to see themselves as scientists and researchers which resulted in changes to their own teaching practices. *Mimicking the actions of scientists* emerged as a sub-category, capturing the changes that directly mirrored their own lab experiences. Teacher participants served as a member of their host labs, allowing them to conduct real and meaningful research while learning about the process of science. Teachers reported mimicking this type of environment in their own classrooms. Allowing students to engage in science discovery, providing more hands-on opportunities, and emphasizing the process and nature of science research outlines the third theme of *science teaching changes.* Teacher participants reported their push to have students collaborate more, participate in more lab experiences, and to move away from "teaching to the test" or the use of worksheets. Our findings suggest that the way teachers perceive their self-efficacy is closely related to the way they implement their teaching. Their comfort and confidence with the science content is related to their willingness to let students have more control in their science classrooms.

Focus on Students

A key focus for participants was finding ways to update their curriculum to engage their students with science content. Rori described her experience with her own students saying,

> I was just bored of the curriculum. I wanted a newer approach, too, because my kids hate science and I have to teach 35 kids who hate what I'm talking about the same thing over and over again and so I was getting stretched, my kids hated it. They would do other things in class and I was just like, 'what can I do to keep them engaged?', 'what can I do to make them like science?

The belief that students hated science was shared amongst several teachers as well as the motivation to change that reality for their students. Dylan recollected her motivation to join the program, stating,

> I have issues with some students, you know, they just have a hard time with science. They think they either love it or they think it is hard and they get overwhelmed. So, I was looking for ways to teach science and make it more interesting to them so that they'll be excited about science.

Later in the focus group, Jay connected with the same frustration that Dylan and Rori shared about their own students' perception of learning science, saying:

> In my experience like a lot of my kids hate it. It's too hard. Especially chemistry. It's too hard, how dare you tie math into a science. Like they just can't wrap their minds around it…they don't want to, but I think knowing that like, hey, I got to be a scientist for summer…and showing them all the different things that you can do in science and it's still called science and you can still feed yourself. I think that will bring more scientist to the field.

As the program progressed, teachers experienced frustrations with a different culture in the lab than in their classrooms, as well as a knowledge gap between themselves and the PhD level scientists. Being immersed into a science learning environment from a students' perspective meant that teachers were now able to connect with their students' perceptions of learning science. Teachers appeared to notice their own feelings in the student role as well as the scientist's responses to their questions and challenges. In essence, the mentors modeled key teaching behaviors as well as the scientific process, which teachers eventually incorporated in their repertoire of skills.

"I was in the same position as my students," Dylan explained as she spoke about how much patience her mentor lab had for her many repeated questions. As the teachers reflected on their experience, patience was a strong component of the culture of the lab, when facing the level of difficulty, they experienced during their research. This was also a key component of their newfound sense of patience for their students' questions. Dylan reflected on her experience of feeling like a student again saying, "So yeah, I also learned that I have to exercise patience with my students because a couple of things I had to ask over and over and my grad student was very patient with me". A similar experience happened to Jay as she described being a student for the second time with a different perspective, reflecting, "It was from a different point of view. Like I was thinking as a student and I was also thinking as a teacher".

Once teachers returned to their classrooms, their focus on the students remained a key motivator for the instructional changes they made. Dylan teaches biology, one of courses that requires students to take a standardized test at the end of the year. In her individual interview she shared a story about her students' test scores and their excitement about science content. She explained:

> As far as my scores, they've always been pretty good, but I had to reflect on what the students need. If we want them to be lifelong learners, we have to teach differently, instead of like teaching just for the test…if we want them to have to have a career in STEM, we have to want them to have an interest in it, not just for the test. So I had some students come to me and asked me to be an advisor for Future Physicians of America, and I was like, honored. And I was like, 'me?' And they were like, 'yes'. So I said, 'okay', so now I'm an advisor for that and we had our first meeting and again, I let them run it. I'm just there, you know, they need an adult presence. So I'm excited about that and I'm just doing more student-based learning so I cannot be exhausted at the end of the day…. more inquiry-based learning and things like that, instead of the way I used to teach.

The shift from maintaining positive test scores to addressing student interest was a commonly shared motivation among teacher participants.

Teaching Self-Efficacy Gains

The coding process brought about several sub-codes including, "resources", "confidence", "relevance", "contributions to the field", and "pride in one's work". These codes comprised the major theme of "teachers' self-efficacy gains". Simply having access to resources does not show evidence of self-efficacy, but the knowledge of how to use new resources suggests that teachers are more prepared for unexpected questions during their instruction. Because teachers spoke about access to resources and it overlapped with data that included feeling more prepared for teaching, "access to resources" was included in this theme.

When asked about her emotions after completing the PD program, Dylan explained, "when I did my poster, I was really proud of it" and in fact, she shared it via social media, with her mother, and with her school administration. Jay had a similar experience of pride as she reflected on the difficulty of the program explaining,

> I think this summer, it was tough… but when we had that last meeting and we had the big poster presentation, like the relief and I mean, it just all came full circle….it was just so worth it. And just to see how hard everybody worked and, you know, how much time and effort. I mean, it was just one of those things where you're just like, okay… I was here for a reason… and I wouldn't have traded it for anything else.

Jay's sense of accomplishing a difficult task provides evidence that her self-efficacy in conducting scientific research, learning, and teaching science has increased. Prior to becoming a science teacher, Rori worked at a bank. During her interview she reported that she had no real training and had to learn how to teach science on her own. Rori spoke about changes in her views towards herself and science teaching explaining,

> I feel like after the program, I'm just more excited about the subject. I'm more excited about the content. I'm more excited about environmental science as a whole. And so, with that excitement I'm able to challenge myself first of all, and I'm able to challenge my students better...I'm like much stronger, not only in the content, but I feel, um, I feel more knowledgeable at teaching.

Additionally, Gabi viewed her experience with pride as she mentioned this experience would serve as an excellent resume builder. She also referred to the resources explaining the immediate relevance and utility of these resources.

When asked, "do you think you can be a scientist?" teachers' responded with a variety of emotions. Blake, Dylan, Jay, and Gabi all reported that though they have proven they are capable of the work, a research lab is too quiet to be fulfilling to them long term. Trey mentioned that after retiring from her teaching career she would be interested in working in a research lab. Pat, Rori, and Kori all expressed interest in furthering their careers in science by going back to school. Pat reflected on her experience in the program stating that "Getting up and going to a lab every day, I had a great time. I'm looking for a PhD program now because you all have really kind of got my wheels turning in my head now. So, I do want to find another program."

Though their aspirations in scientific research differ, the teachers all left the program with a sense of pride in completing the program and knowing that they can conduct research.

Instructional Changes

As teacher participants continued to focus on the students in their science classrooms while being immersed in a science research lab, ways of incorporating the process of science began to emerge in conversations. Additionally, once returning to their classrooms, teacher participants spoke about applying what they'd learned in the labs to their own classrooms. The coding process brought about two major sub-categories that make up the theme *science teaching changes*: mimicking the behavior of scientists and changes to practice. Mimicking the actions of scientists and science teaching changes coincided during the coding process and were therefore combined. This theme captures teachers' emphasis on the process of science in their classrooms, the implementation of aspects from their lab experience into their classroom, and the general experience of being a scientist including disappointments, discoveries, and collaboration.

After their PD experience, teachers returned to classrooms. The choice to make any changes was entirely up to them. Knowledge and skills transferred from the PD program are represented by teachers' reports of a post PD-participation shift in their instructional styles or strategies.

Trey, one of the teachers, summarized her thoughts about her science teaching by saying, "I think that by this experience we've actually come up with some ways to alter or change or add into what we already have in the classroom". Teachers consistently reported making changes in their classroom to accommodate a "more hands on" approach. Dylan reflected on her previous approach to classroom management that consisted of keeping more control of her classroom, but after her PD experience she committed to, "being more intentional with the students being more in control of the class". She explained that her approach to questions in her classroom has changed and that she's, "making them think now on a higher level", by not simply asking for a correct answer, but asking "why did you choose that answer?". When asked about her overall experience in the lab, Dylan responded, "I enjoyed learning. Again, I'm reinforcing the scientific method part". Her challenge to her students to think beyond the correct answer and her reinforcement of the use of the scientific method are consistent with her own lab experience. Other teachers had a similar view on teaching science and shifted to approach science through a hands-on experience. Rori explained her shift in teaching practices saying,

> Most of the stuff in the class is hands on now. I have gotten away from trying to just get my kids ready for the exam because I've found that being that strict, being that rigid, that tough on students does not help them at all.

Kori had a similar experience when she returned to her classroom explaining "one of the big things that I did this year was I really looked at my curriculum and I ensured that I was doing as many labs and activities as possible. So, by this time last year I probably had only done about four labs and this time this year I've done eight". Further, Kori explained that she was also emphasizing more about, "why those procedures are important" and stressing the need to understand the scientific process so that they can analyze experiments and their results. Adapted from her own lab experience, she emphasized the methods her students use to better understand the nature of scientific research. Additionally, she reflected on her values from the program stating, "So for me it was just a better understanding of the scientific method on a larger scale and how I can apply that to the small scale we do here". Gabi's approach to her classroom mirrored her experience in the lab as she stated, "they're going to do a research project like the one that I have". Her approach to her classroom assignments suggest that she is modeling the nature of scientific inquiry that she learned in her lab experience.

Another change to teaching practices included collaboration with one another to eliminate cheating. After a presentation on research ethics outlining consequences for plagiarism, Trey was inspired to take the same approach in her own classroom. She explains,

> "The idea that I want to steal is the whole "retracted" idea because if your data matches this group, "retracted!" You know. You get a stamp and you're going to get the lowest possible passing grade on that particular lab because that's what they're doing in the real world. So, they need to start learning this at a younger age and that's something that I'm going to put in my syllabus".

Kori also emphasized collaboration without copying in her classroom as she adapted her own lab experience to fit her classroom. She explains her new approach, saying,

> "I do more discussions and do more student-centered interactions and discussions than I did last year. um, so, you know, a little bit more lab work, teamwork, collaborative work, which was something that was required and when we did the research. It's not really just a one-person effort, especially whenever you're doing tests every single day. It always requires somebody else's input, somebody else's help. So that was something that I was able to incorporate more into my setting."

Overall, teachers were proud of the work they accomplished during their PD experience and made meaningful changes to their science teaching practices.

Discussion

The three major themes capturing the key findings in our study reflect how teachers gained more teaching science efficacy, made instructional changes to their teaching, and focused more on helping students develop academically. These findings answer the proposed research questions by providing an indication that teachers made various types of changes (i.e., instructional, motivational), due to their immersive science mentorship program engagement.

Throughout the PD experience, teacher participants' focus remained on their students. This focus ranged from connecting with their students' experiences to imagining ways to bring their lab experience back to their classrooms. Teacher participants remained motivated to providing relevant experiences for their students. Many teachers were inspired to change their teaching practices by experiencing learning through their students' perspectives. This finding of understanding student thinking is consistent with Borko (2004) suggestions of meaningful professional development experiences.

Through immersion in a research lab, teachers were provided with models of how science inquiry happens in the field. The overall PD experience presented many challenges to each of the teachers. One of the most common challenges was the difference in knowledge base between the teachers and the scientists. Overcoming these challenges led to more confidence in the research labs as well as more comfort with the scientific process. As the teachers' knowledge and experience in the lab increased, questions were viewed less as a distraction and threat and became more of the guiding practice of scientific learning. These results are consistent with Bandura's (1977) theory of self-efficacy stating, "efficacy expectations determine how much effort people will expend and how long they will persist in the face of obstacles and aversive experiences. Those who persist in subjectively threatening activities that are in fact relatively safe will gain corrective experiences that reinforce their sense of efficacy" (Bandura, 1977, p. 194). Once teachers understood what it was like to be in the position of the student who asks questions, they were more inclined to welcome these questions and use them to deepen their students' inquisitiveness. This was all modeled by their host labs and supports that vicarious learning and having models is incredibly influential in teacher professional development (Schunk, 2012).

Teachers were supplied with many new resources that were relevant to their teaching and to their students. These resources and the knowledge of how to use them provided teachers with the knowledge they needed to answer questions or to challenge their students to dig deeper to find their own answers. Having access to resources and relationships is a requirement to inquiry-based instruction (Johnson, 2006).

After returning to their classrooms, teachers described their teaching approach as "more hands on". Simply being "more hands on" does not necessarily mean they were using inquiry-based learning, however, their emphasis on the scientific method, understanding the process, letting questions guide the learning, and investigating phenomena are all evidence of inquiry-based learning (Crawford, 2007). Furthermore, the teachers increase in lab and activity engagement, as well as letting students have more control over their learning is further evidence that teachers are using inquiry-based instruction and suggests they are "modeling the actions of scientists" (Crawford, 2007, p. 614).

Limitations and Ethical Considerations

In this study, teachers reported the changes made in their teaching practices. Research did not include observations or more empirical evidence of these changes. Demographic information was collected in the surveys and interview questions. The research questions do not directly address how one's race, ethnicity, age, or socioeconomic status play into their beliefs about science teaching, therefore, these aspects were not included to avoid further marginalizing these identities. Participants were paid a stipend for their participation in the program issued based on participation and attendance in the program. All participants were made aware of this at the beginning of the program.

Recommendations

This research adds to the growing body of research surrounding science education reform through the professional development of science teachers. Teacher professional development can be an incredibly influential experience for science teachers when it involves opportunities to learn from scientists who model scientific inquiry, it lasts long enough to see their own growth, and it provides resources for their success in the classroom. To see the impact of professional development, long-term, immersive experiences offer a great chance to see real changes in scientific teaching. The future of STEM careers starts in the science classroom, but if our teachers are not confident in their subject, our students may struggle to connect to the material (Thomson & Gregory, 2013; Thomson, Huggins, & Williams., 2019). When school districts and administration can send their new science teachers to meaningful professional development experiences, they should support this endeavor. For teachers who are struggling with science content and instruction, long-term professional is an influential experience resulting in better practices in science teaching.

References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of science teacher education*, *13*(1), 1–12. https://doi.org/10.1023/A:1015171124982

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, *84*(2), 191. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: Freeman.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Bayar, A. (2014). The components of effective professional development activities in terms of teachers' perspective. *Online Submission*, *6*(2), 319–327. https://doi.org/10.15345/iojes.2014.02.006

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15. https://doi.org/10.3102/0013189X033008003

Capps, D. K., & Crawford, B. A. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education*, *24*(3), 497–526. https://doi.org/10.1007/s10972-012-9314-z

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching, 37*(9), 916–937.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of research in science teaching*, *44*(4), 613–642. https://doi.org/10.1002/tea.20157

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches, 4th edition.* Thousand Oaks, CA: Sage.

DeCoito, I., & Myszkal, P. (2018). Connecting science instruction and teachers' self-efficacy and beliefs in STEM education. *Journal of Science Teacher Education*, *29*(6), 485–503. https://doi.org/10.1080/1046560X.2018.1473748

Johnson, C.C., Mohr-Schroeder, M.J., Moore, T.J., & English, L.D. (2020). *Handbook of research on STEM education*. New York: Routledge.

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers science teachers encounter and implications for reform. *School science and mathematics*, *106*(3), 150–161. https://doi.org/10.1111/j.1949-8594.2006.tb18172.x

Klein-Gardner, S. S., Johnston, M. E., & Benson, L. (2012). Impact of RET teacher-developed curriculum units on classroom experiences for teachers and students. *Journal of Pre-College Engineering Education Research*, *2*(2), 21–35. https://doi.org/10.5703/1288284314868

Martin, A., Park, S., & Hand, B. (2019). What happens when a teacher's science belief structure is in disequilibrium? Entangled nature of beliefs and practice. *Research in Science Education*, *49*(3), 885–920. https://doi.org/10.1007/s11165-017-9644-0

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). Fundamentals of qualitative data analysis. *Qualitative data analysis: A methods sourcebook*, 69–103.

National Research Council (NRC). (1996). National Science Education Standards. Washington, D.C.: National Academy Press.

Schunk, D. H. (2012). *Learning theories an educational perspective sixth edition*. Pearson.

Schunk, D. H., & Pajares, F. (2002). The development of academic self-efficacy. In A. Wigfield & J. S. Eccles (Eds.), A Vol. in the educational psychology series. *Development of achievement motivation* (p. 15–31). Academic Press.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research techniques.* Thousand Oaks, CA: Sage.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching*, *37*(9), 963–980. https://doi.org/10.1002/1098-2736(200011)37:9<963::AID-TEA6>3.0.CO;2-0

Thomson, M. M., Roberts, R., & Hubbard, L. (January, 2020). *Motivations and values: Immersive mentorship science experiences.* Presentation at the National Institute on the Teaching of Psychology (NITOP), St Petersburg, FL.

Thomson, M. M., Huggins, E. & Williams, W. (2019). Developmental science efficacy trajectories of novice teachers from a STEM-focused program: A longitudinal mixed-methods investigation. *Teaching and Teacher Education, 77,* 253–265. https://doi.org/10.1016/j.tate.2018.10.010

Thomson, M. M., & Nietfeld, J. (2016). Beliefs systems and classroom practices: Identified typologies of elementary school teachers from the United States. *The Journal of Educational Research*, *109*(4), 360–374. https://doi.org/10.1080/00220671.2014.968912

Thomson, M. M., & Turner, J.E. (2015). Teaching motivations, characteristics and professional growth: Results from the Great Expectations (GE) programme in the United States. *Educational Psychology, 35*(5), 578–597. https://doi.org/10.1080/01443410.2013.849796

Thomson, M .M., & Gregory, B. (2013). Elementary teachers' classroom practices and beliefs in relation to US science education reform: Reflections from within. *International Journal of Science Education*, *35*(11), 1800–1823. https://doi.org/10.1080/09500693.2013.791956

Wilson, S. M. (2013). Professional Development for Science Teachers. *Science*, *340* (6130), 310–313. https://doi.org/10.1126/science.1230725

Yin, R. K. (2014). *Case study research: Design and method* (5th ed.). Thousand Oaks, CA: Sage.

Zimmerman, B. J., & Schunk, D. H. (2003). Albert Bandura: The scholar and his contributions to educational psychology. In B. J. Zimmerman & D. H. Schunk (Eds.), *Educational psychology*: A century of contributions (pp. 431–457). Mahwah, NJ: Erlbaum.

Corresponding Author: Lindsey Hubbard
Email: lehubbar@ncsu.edu

Appendix A
Sample questions from interview protocol

1. Describe a little bit your science teaching efficacy:
a) *before* and *after* your PD program.
b) at the present time: How confident are you now about your science teaching related to the EHS topic?
2. What do you consider to be the most valuable about your participation in the EHS program?
3. Can you talk a little bit about your emotions *before* and *after* your EHS summer PD program?
4. Please describe what changes in your teaching practices you made after attending the EHS program and how the EHS program provided the impetus for you to make these changes.
5. In what ways does your school and district provides support for you to implement in your teaching the knowledge and skills you gained from attending the EHS program?

Appendix B
Coding scheme with major themes and codes

Themes	Codes/Sub-codes	Description
1. Focus on the Student	1.1 Student desire/interest/needs 1.2 Students' perceptions of learning science 1.3 "Absolutely, my students can be scientists" 1.4 Proof to students 1.5 Student Initiative in learning science 1.6 "I was in the same position as my students"	Participant's motivation for completing this program, focus on student interest in science learning, seeking ways to further engage students in science learning, beliefs about students' ability to learn and do science, connecting with students' role as learner
2. Resources	2.1 "Something to take back" 2.2 Relevant research 2.3 Relationships built	Exposure to equipment in the lab, exposure to relevant research, tangible resources to take back to classroom, network of people as resources
3. Frustrations in the program	3.1 Lab Culture Vs Classroom Culture 3.2 Boredom in the Lab 3.3 Payment Misunderstandings 3.4 Steep Learning Curve	Expressed frustrations during the program
4. Mimicking the behavior of Scientists	4.1 Acting like Scientists 4.2 The process of science 4.3 Collaboration in research 4.4 "Real authentic research" 4.5 Comfort with starting over 4.6 Comfort with more questions	Practicing the scientific method, strict lab procedures, encouraging collaboration, and following the nature of scientific research "when I got through with my experience with my experiments like the data wasn't significant even dr. Reid was like man I was hoping that we could find something sometimes you just don't end

		up with anything and you just have to start over and look at something else a different Locus"
5. Teacher efficacy gains from Program	5.1 Confidence 5.2 Comfortable 5.3 Pride in one's work 5.5 Excitement towards science	Expressed confidence, comfort, and excitement with science content, research, and teaching science and sense of pride in completing the program.
6. Changes to practice	6.1 More hands on 6.2 More patience for student questions 6.3 Students guide learning 6.4 former teaching practices	Changes to science teaching practices after PD program, reference to former teaching practices
7. Perceived low support from school	7.1 School administration is disconnected from classroom 7.2 School administration is focused on other things 7.3 focus on scores	Participants' expressed perception of school administration not focusing on the experience of students in science classrooms and only focusing on scores, a belief that support only comes for tested subjects (i.e. biology)
8. Science as a future career	8.1 Resume builder 8.2 Seeking higher degree 8.3 Future aspirations	Participants thinking about their future possibilities in science and science teaching.